CLAIMS

1. A wireless communication system, comprising:

a control apparatus;

at least one relay apparatus connected with the control apparatus via an optical transmission path; and

a plurality of wireless communication terminals communicating wirelessly with the relay apparatus;

wherein:

the control apparatus comprises:

a first optical transmitting section for converting a downstream electric signal into a downstream optical signal and transmitting the downstream optical signal to the relay apparatus via the optical transmission path, and

a first optical receiving section for converting an upstream optical signal transmitted from the relay apparatus via the optical transmission path into an upstream electric signal;

the relay apparatus comprises:

a second optical receiving section for converting the downstream optical signal transmitted from the control apparatus via the optical transmission path into the downstream electric signal;

a transmitting/receiving antenna section for transmitting the downstream electric signal converted by the second optical receiving section to the wireless communication terminal

as a wireless signal, and receiving a wireless signal transmitted from the wireless communication terminal as the upstream electric signal; and

a second optical transmitting section for converting the upstream electric signal received by the transmitting/receiving antenna section into the upstream optical signal and transmitting the upstream optical signal to the control apparatus via the optical transmission path; and

the wireless communication system further comprises wireless signal level restriction means for adjusting the level of a wireless signal transmitted or received by the relay apparatus such that a receiving level of the wireless signal received by the relay apparatus is kept within a predetermined range.

2. A wireless communication system according to claim 1, wherein, where the wireless communication terminals use a respective channel, the predetermined range is smaller than a difference between (a) a leakage ratio which is the ratio of the level of a wireless signal using the respective channel with respect to the level of a frequency component leaking to another channel different from the respective channel, and (b) a signal to noise ratio which is the ratio of the level of a leakage signal from a wireless communication terminal using another channel different from the respective channel with respect to the level of the wireless signal using the respective channel.

3. A wireless communication terminal according to claim 2,

wherein:

the wireless signal level restriction means is a level control section, provided in the relay apparatus, for adjusting the level of the downstream electric signal which is output by the second optical receiving section; and

the level control section attenuates the level of the downstream electric signal so as to narrow a communicable area of the relay apparatus, and thus allows the level of a wireless signal transmitted by a wireless communication terminal existing in the communicable area to be within the predetermined range.

4. A wireless communication system according to claim 2, wherein:

the control apparatus comprises a plurality of the first optical transmitting sections;

the wireless signal level restriction means is a signal dividing section, provided in the control apparatus, for dividing the downstream electric signal;

the signal dividing section divides the downstream electric signal and thus attenuates the level of the downstream electric signal so as to narrow a communicable area of the relay apparatus, and thus allows the level of a wireless signal transmitted by a wireless communication terminal existing in the communicable area to be within the predetermined range; and

the first optical transmitting sections convert the downstream electric signals divided by the signal dividing section

into downstream optical signals.

5. A wireless communication system according to claim 2, wherein:

the wireless signal level restriction means is a pilot signal generation section, provided in the control apparatus, for generating a pilot signal to be transmitted while being superposed on the downstream electric signal;

the first optical transmitting section converts the downstream electric signal having the pilot signal superposed thereon into a downstream optical signal;

the relay apparatus further comprises:

a pilot signal detection section for detecting the level of the pilot signal superposed on the downstream electric signal converted by the second optical receiving section; and

a level control section for controlling the level of the wireless signal such that the level of the pilot signal detected by the pilot signal detection means is constant; and

the pilot signal generation section increases the level of the generated pilot signal so as to narrow a communicable area of the relay apparatus, and thus allows the level of a wireless signal transmitted by a wireless communication terminal existing in the communicable area to be within the predetermined range.

6. A wireless communication system according to claim 2, wherein:

the wireless signal level restriction means is provided in

the control apparatus, and comprises:

a monitoring section for monitoring whether or not the quality of the upstream electric signal converted by the first optical receiving section fulfills a predetermined condition; and

a level control section for, when the monitoring section determines that the quality of the upstream electric signal does not fulfill the predetermined condition, lowering the level of the downstream electric signal which is to be input to the first optical transmitting section so as to reduce an optical modulation index; and

the level control section reduces the optical modulation index and thus attenuates the power of the downstream optical signal so as to narrow a communicable area of the relay apparatus, and thus allows the level of a wireless signal transmitted by a wireless communication terminal existing in the communicable area to be within the predetermined range.

7. A wireless communication system according to claim 2, wherein:

the wireless signal level restriction means is provided in the control apparatus, and comprises:

a monitoring section for monitoring whether or not the quality of the upstream electric signal converted by the first optical receiving section fulfills a predetermined condition; and

a level control section for, when the monitoring section determines that the quality of the upstream electric signal

does not fulfill the predetermined condition, lowering the level of a bias current which is set by the first optical transmitting section so as to reduce an optical modulation index; and

the level control section reduces the optical modulation index and thus attenuates the power of the downstream optical signal so as to narrow a communicable area of the relay apparatus, and thus allows the level of a wireless signal transmitted by a wireless communication terminal existing in the communicable area to be within the predetermined range.

8. A wireless communication system according to claim 2, wherein the wireless signal level restriction means includes a level attenuation section for attenuating the wireless signal to such a level that the upstream optical signal converted by the second optical transmitting section is not distorted.

9. A wireless communication system according to claim 2, wherein:

communicable areas of the relay apparatuses adjacent to each other partially overlap each other;

the relay apparatuses each comprise level adjustment means for controlling a gain by adjusting the level of the wireless signal transmitted to, and received from, the wireless communication terminal; and

the level adjustment means adjusts the level of the wireless signal, such that a difference between (a) a delay time required for a signal transmitted from the control apparatus to be

transmitted via each of the adjacent relay apparatuses onto the wireless communication terminal existing in a region where the communicable areas overlap each other, and (b) a delay time required for a signal transmitted from the control apparatus to be transmitted via the relay apparatus adjacent to the each relay apparatus onto the wireless communication terminal existing in the region where the communicable areas overlap each other, is within a predetermined time period.

10. A wireless communication system according to claim 9, wherein, where two relay apparatuses adjacent to each other is one set, one set of adjacent relay apparatuses communicate using a frequency which is different from the frequency used by another set of adjacent relay apparatuses.

11. A communication system according to claim 9, wherein the transmitting/receiving antenna section has a directivity toward a relay apparatus, among the two adjacent relay apparatuses, which is connected with the control apparatus via a longer optical transmission path than the optical transmission path which connects the control apparatus and the relay apparatus including the transmitting/receiving antenna section.

12. A wireless communication system according to any one of claims 9 through 11, further comprising an optical splitting/coupling section for splitting the optical transmission path which connects the control apparatus and each of the relay apparatuses, wherein one end of the split optical fiber is connected

to the relay apparatus and the other end is connected to another optical splitting means.

13. A wireless communication system according to any one of claims 9 through 11, wherein the optical splitting/coupling section splits one optical fiber connected to the control apparatus into at least a predetermined number of optical fibers, and each of the split optical fibers is connected to a relay apparatus.

14. A wireless communication system according to claim 9, wherein the level adjustment section adjusts the level of the wireless signal such that the delay times are each a maximum delay time tolerated by the wireless communication system.

15. A wireless communication system according to claim 2, wherein:

communicable areas of the relay apparatuses adjacent to each other partially overlap each other;

the relay apparatuses each comprise optical signal control means for controlling a delay time of the optical signal transmitted to, and received from, the control apparatus; and

the optical signal control means controls the delay time of the optical signal, such that a difference between (a) a delay time required for a signal transmitted from the control apparatus to be transmitted via each of the adjacent relay apparatuses onto the wireless communication terminal existing in a region where the communicable areas overlap each other, and (b) a delay time required for a signal transmitted from the control apparatus to

be transmitted via the relay apparatus adjacent to the each relay apparatus onto the wireless communication terminal existing in the region where the communicable areas overlap each other, is within a predetermined time period.

16. A wireless communication system according to claim 1, wherein:

the transmitting/receiving antenna section has such a directivity that a receiving sensitivity thereof in a vertical direction is within the predetermined range; and

the predetermined range is a range tolerated by the second optical transmitting section.

17. A wireless optical transmission system according to claim 16, wherein the wireless signal level restriction means is a radiowave absorber, provided in the transmitting/receiving antenna section, for absorbing a wireless signal transmitted from the vertical direction.

18. A wireless optical transmission system according to claim 16, wherein:

the transmitting/receiving antenna section includes a pole antenna having a two-way directivity; and

the pole antenna is installed such that a receiving sensitivity thereof in a vertical direction is within a predetermined level.

19. A wireless optical transmission system according to claim 18, wherein the pole antenna is installed on a ceiling of a building.

20. A wireless optical transmission system according to claim 18, wherein the pole antenna is installed on a floor of a building.

21. A wireless optical transmission system according to claim 18, wherein the pole antenna is installed on a wall of a building.

22. A wireless optical transmission system according to claim 16, wherein the transmitting/receiving antenna section comprises:

a receiving antenna section for transmitting the downstream electric signal converted by the second optical receiving section to the wireless communication terminal as a wireless signal; and

a transmitting antenna section for receiving a wireless signal transmitted from the wireless communication terminal as the upstream electric signal;

wherein the wireless signal level restriction means is the transmitting antenna section and is provided at such a position that the transmitting antenna section shields a wireless signal transmitted from the vertical direction.

23. A wireless optical transmission system according to claim 22, wherein the transmitting antenna section has a directivity in a direction excluding a direction in which the receiving antenna section is provided.

24. A wireless communication system according to claim 16, wherein, where the wireless communication terminals each use a respective channel, the wireless signal level restriction means further comprises a level attenuation section for attenuating the level of a signal received by the transmitting/receiving antenna

section, and keeping a signal to noise ratio which is the ratio of the level of a leakage signal from a wireless communication terminal using another channel different from the respective channel with respect to the level of a wireless signal using the respective channel to a predetermined value or lower.

25. A wireless optical transmission system according to claim 16, wherein:

each of the transmitting/receiving antenna sections has a unidirectivity with which a wireless signal from a wireless communication terminal located right below the each transmitting/receiving antenna section is not received, and receives a wireless signal transmitted from a wireless communication terminal existing in a receivable area with a predetermined level;

at least one of the transmitting/receiving antenna sections is located in a direction in which the unidirectivity is directed, and receives a wireless signal from the wireless communication terminal located right below the transmitting/receiving antenna section of the relay apparatus adjacent to the at least one transmitting/receiving antenna section; and

the predetermined level is within the predetermined range.

26. A wireless optical transmission system according to claim 25, wherein among the transmitting/receiving antenna sections, the transmitting/receiving antenna sections of the relay apparatuses, other than the relay apparatus located at the shortest

distance in the direction represented by the unidirectivity, are located in the direction in which the unidirectivity is directed and receive a wireless signal from the wireless communication terminal located right below the transmitting/receiving antenna section of the relay apparatus adjacent to the transmitting/receiving antenna sections.

27. A wireless optical transmission system according to claim 26, wherein the unidirectivity of each of the transmitting/receiving antenna sections is a directivity toward a direction right below the transmitting/receiving antenna section of the relay apparatus adjacent in an oblique downward direction with respect to the vertical direction.

28. A wireless optical transmission system according to claim 27, wherein receivable areas of the relay apparatuses adjacent to each other partially overlap each other.

29. A wireless optical transmission system according to claim 28, wherein:

the transmitting/receiving antenna section has a unidirectivity toward a relay apparatus, among the adjacent relay apparatuses, which is connected with the control apparatus via a longer optical transmission path than the optical transmission path which connects the control apparatus and the relay apparatus including the transmitting/receiving antenna section; and

the unidirectivity is adjusted such that a difference between (a) a delay time required for a wireless signal transmitted from

a region where the receivable areas overlap each other to be received by the transmitting/receiving antenna section and transmitted onto the control apparatus, and (b) a delay time required for the wireless signal to be received by the transmitting/receiving antenna section of the adjacent relay apparatus and transmitted onto the control apparatus, is within a predetermined time period.

30. A wireless optical transmission system according to claim 29, wherein the unidirectivity is adjusted by changing an expansion angle of the unidirectivity.

31. A wireless optical transmission system according to claim 29, wherein the unidirectivity is adjusted by changing an angle at which the transmitting/receiving antenna section is installed.

32. A wireless optical transmission system according to claim 29, wherein:

the relay apparatus further comprises a level adjustment section for amplifying or attenuating a wireless signal received by the transmitting/receiving antenna section;

the level adjustment section amplifies or attenuates the wireless signal such that the level of the wireless signal transmitted from the region where the receivable areas overlap each other is a predetermined level; and

the predetermined level is such a level that a difference between the predetermined level and the level of a wireless signal transmitted from the region where the receivable areas overlap

each other and received by the adjacent relay apparatus is within a predetermined range.

33. A wireless optical transmission system according to claim 16, wherein the wireless communication terminals communicate using wireless signals having different frequencies from one another.